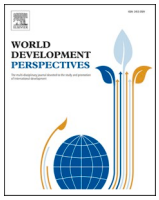
World Development Perspectives 23 (2021) 100347

Contents lists available at ScienceDirect

World Development Perspectives

journal homepage: www.sciencedirect.com/journal/world-development-perspectives



Does a portfolio of consumption adjustment coping strategies erode resilience? Panel data evidence from Ethiopia

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ARTICLE INFO

Keywords:
Coping strategies
Nutrition
Ethiopia

ABSTRACT

For smallholder subsistence farmers, it is difficult to undertake adequate ex-ante strategies to prepare for shocks. These households are forced to attempt multiple ex-post coping strategies such as consuming less preferred food, limiting food diversity and reducing the size of meals. The literature on consumption has generally overlooked the potential impact of post-shock consumption adjustment on nutritional deprivation. This paper uses panel data sets in rural communities of Ethiopia to provide empirical evidence on households' decisions on portfolios of ex-post consumption adjustment and their impact on dietary intake, using an endogenous switching treatment effects approach. Our results show that the choices of coping strategies differ with the level of asset ownership and extent of shocks. However, the non-linear relationship between assets and coping strategies reveals the co-existence of consumption smoothing and consumption adjustment coping actions. The empirical results show that the choice of any of the coping strategies, whether individually or jointly, results in greater undernourishment, which suggests that ex-post coping actions may erode resilience by causing nutritional deprivation. The findings suggest closing the adaptation deficit to increase resilience to shocks.

1. Introduction

Many households in developing countries face difficulties in gaining stable and adequate access to nutritious food. Vulnerable households in these areas encounter substantial risks because their lives and livelihoods are inseparably associated with natural calamities. The increasing risks due to climate and non-climate factors, such as lack of natural and economic resources, have greatly contributed to household income fluctuations and consumption deficits (Hill & Porter, 2017), which leads to food insecurity and nutritional deprivation. Accordingly, studies call for building livelihood resilience and reducing vulnerability with effective adaptation options so that a household is better prepared to cope with the impacts of shocks and to adapt to changing conditions (Teklewold et al., 2017; Asfaw et al., 2018).

Undeniably, the fact that household nutrition and resilience are strongly intertwined means that efforts to reduce under-nutrition are salient to building up resilience as well. This is because better nourished households are healthier, can work harder, and have greater physical reserves, and households that are nutrition-secure are thus better able to withstand external shocks (FAO, 2014). A compelling body of evidence suggests that the degree to which households increase their resilience is dependent on their ability to implement adaptation mechanisms ex-ante, whereby the household prepares for a shock in order to avoid or minimize exposure to risk (Asfaw et al., 2018; Abid et al., 2020).

However, with an adaptation deficit, where it is difficult for the household to adopt ex-ante adaptation options or when these are insufficient, households are forced to undertake ex-post coping strategies by way of consumption smoothing and asset smoothing (Kumar & Quisumbing, 2014). While adaptation is a non-stop process that is forward looking and directed towards long-term livelihood security, coping is a short-term, responsive, instantaneous, non-continuous act driven by disaster and concerned with household survival (Birkmann, 2011; Asfaw et al., 2018). Poor households are usually more occupied in coping with climate impacts than in adapting to climate change. Thus, because the consequences of most of the coping actions could potentially exacerbate households' vulnerability to shocks, they are referred as erosive coping (Quandt, 2021).

In ex-post shock responses, poorer households usually opt for

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https://doi.org/10.1016/j.wdp.2021.100347
Received 4 November 2020; Received in revised form 9 July 2021; Accepted 24 July 2021
Available online 5 August 2021

consumption smoothing at first by drawing down their assets until the productive assets reach the level of Micawber's threshold[1]; then the households switch to asset smoothing to maintain assets and safeguard their future survival (Zimmerman & Carter, 2003). Poor households sometimes turn back from asset smoothing to consumption smoothing when their immediate survival is at risk (Dercon, 2002). In practice, in Ethiopia as well as many of the African countries, the austerity measures in food consumption patterns have three salient features. First, to the extent that consumption smoothing fails, a household decides to reduce the amount of food consumption below what it would be in the absence of the shock. Second, consumption smoothing is partly achieved through reducing the variety of foods. Thirdly, food consumption is maintained partly through consumption of less preferred and poorer quality foods (Abid et al., 2020).

Although consumption changes are easily adjustable coping strategies, they result in adverse consequences in household food consumption and dietary shortfalls due to low consumption of essential micronutrients, the result of which is a high prevalence of micronutrient deficiency related diseases (FAO, 2011). Ex-post coping actions impact households' nutrition security through limiting the availability and consumption of diverse, safe, and nutritious foods associated with dietary recommendations (FAO, 2014; Gupta et al., 2015). This implies that such coping strategies can have adverse consequences in terms of nutrition and cognitive development as well as economic outcomes, and thus they erode the resilience of households to shocks (Takasaki et al., 2004; Alderman et al., 2006; Hoddinott, 2006; Kumar & Quisumbing, 2014). Unfortunately, rigorous empirical evidence that assesses the impact of consumption adjustment coping strategies on delivering adequate quantities of nutritionally balanced food is rare.

Moreover, the literature shows that individual coping strategies employed by households often do not fully buffer the adverse impacts of shocks, and different strategies may be undertaken by the household at the same time or sequentially, with each one having distinct effects (Yilma et al., 2014; Gao & Mills, 2018). However, there is a paucity of information on conditioning factors that affect the choice of multiple ex-post coping strategies and their individual and joint effects on household nutritional status. While many recent empirical studies explore adoption of coping strategies among rural households, to the best of our knowledge, there has been no empirical evidence to date to explain households' decisions on choices of portfolio of ex-post consumption adjustment coping mechanisms in the presence of weather shocks, and their impact on household nutrition security such as consumption of calories, protein, and iron. Examining how the burden of reduced food consumption strategies in terms of nutritional deprivation is spread amongst rural households at times of crisis is a very important issue, where the relative lack of such evidence can have serious consequences for the design of effective early warning systems and disaster relief programs.

Studying the choice of portfolios of consumption adjustment coping strategies and households' nutrition security in the case of Ethiopia is interesting in three ways. First, climate shocks are substantial; in particular, most farm households are recurrently exposed to drought. Second, although food security has become the main pillar of government policy in the past decades, Ethiopia is still one of the less developed countries in sub-Saharan Africa, where financial and insurance markets are imperfectly functioning, making it more difficult to undertake efficient responses to the risk of drought. Finally, panel data exist for more than 3300 rural households covering 2012–2016, which includes the most recent drought in 2015. Data have been collected both on the actual responses of households to drought and on quantity of consumption of different type of foods.

The paper is structured as follows. The next section describes the survey and summarizes the data used in the analysis. The third section discusses the empirical econometric framework. The fourth section presents estimation results on the determinants of choice of coping actions and their impact on nutrition outcomes. The last section concludes.

2. Data and methodology

2.1. Survey description

The data used in the ensuing analysis are from the Ethiopian Socioeconomic Survey (ESS), a panel household survey collected by the Central Statistical Agency (CSA) with the support of the Living Standards Measurement Surveys – Integrated Surveys in Agriculture (LSMS-ISA) project of the World Bank. The survey was implemented in 2012, with two additional rounds of data collection in 2014 and 2016, with sample sizes of 3420, 3310 and 3272 farm households, respectively. Overall, the attrition rate is about 5% (4% for the 2014 round and 3% for the 2016 round). The dataset comprises rural households from ten different regions of the country[2]. The survey collected information covering a wide range of topics, including household information on basic demographics; food consumption patterns and expenditure; household nonfarm activities; current shocks; safety nets; livestock and land holdings; the different coping strategies adopted; and geo-referenced household level latitude and longitude coordinates to establish historical metrological data such as rainfall and temperature.

2.2. Description of variables – Choice, control and outcome

2.2.1. Choice variables: Coping actions

We derive an indicator of ex-post consumption adjustment coping strategies from the respondent's answer to the question "What do you do when you do not have enough food, and do not have enough money to buy food?" The response to this question indicates whether the household undertakes any coping strategies and also describes details of the type of coping mechanisms. The consumption adjustment strategies are then grouped into three categories: consumption of less preferred and less expensive foods; reduce food diversification by limiting the variety of foods; and reduce number of meals per day and/or limiting the portion size of foods. Fig. 1 depicts the participation rate in the different ex-post coping strategies. The consumption adjustment patterns and the frequency of responses for each strategy across the whole sample and for each survey year show that the use of multiple coping strategies is common among households in the study areas. On average, about 40% of households have used more than one coping strategy. Close to 15% of the households choose the three coping strategies jointly while only 2–6% of households employ these strategies individually. Simultaneous adoption of the three coping strategies is reduced from 20% in 2012 to 11–13% in the latter survey years.

Table 1 reports a series of coping strategies adopted jointly. The possible correlation among the three coping strategies is also presented in Table 2 to highlight the conditional and unconditional participation probabilities of the coping strategies. On average, the three coping strategies – consumption of less preferred foods, reduce variety of foods and reduce size of foods – are used by 29%, 26% and 24% of farm households, respectively. However, the probabilities of use of these coping strategies in the presence of the other strategies are higher than using each strategy solely. For instance, the choice of consumption of less preferred food is more common for those households who also choose to reduce variety of foods or reduce quantity of foods or both. Similarly, consumption of less diversified food is also common when the

[1] The "Micawber threshold" is a level below which the household will fall into a poverty trap and may not be able to recover unless supported with external sources (Lipton, 1994).

[2] These include Tigray, Afar, Amhara, Oromia, Somali, Bensahngul-Gumuz, Southern Nations and Nationalities People (SNNP), Gambelia, Harari and Dire Dawa.

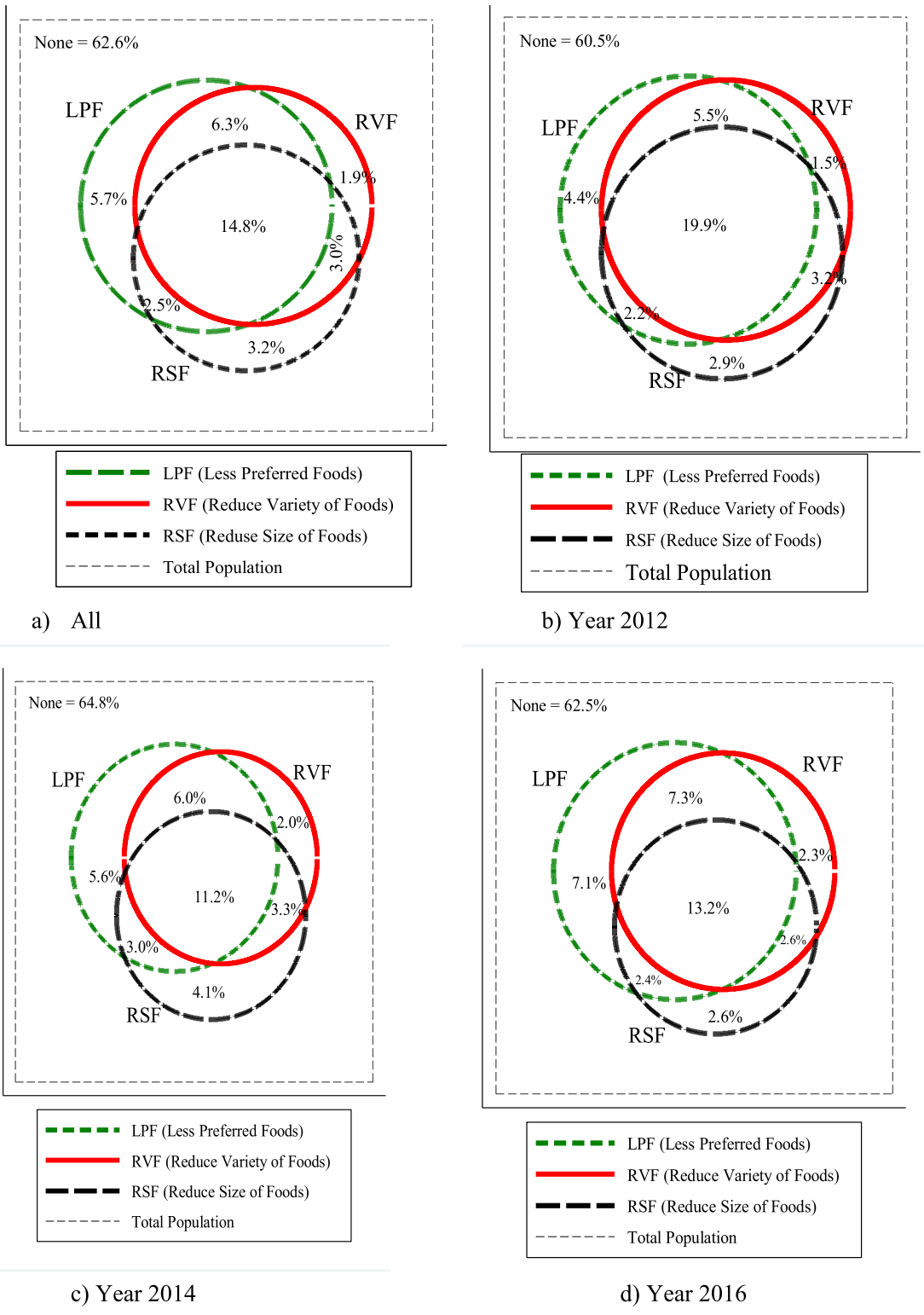

Fig. 1. Adoption probabilities (%) of coping strategies: Less Preferred Food (LPF); Reduce Variety of Foods (RVF); Reduce Size of Food (RSF).

households choose either to consume less preferred foods or decide to reduce the quantity of foods (individual adoption), but the choice of less diversified food is even more common for those households who adopted the other two coping strategies jointly.

Table 3 presents the shift in choice of coping strategies over time. We noted the change in the choice of the different coping strategies between 2012, 2014 and 2016. Close to 60% of households change their choice of coping strategies over the years. Out of the remaining 40% of households who keep their status over the years, 30% of the households never use the coping strategies and 10% of the households are always engaging in one or more of the coping strategies. With regard to each coping strategy, while we notice change in choice of individual coping strategies over time, the majority of the households are immobile in their participation status during the survey years. For instance, about 40, 45 and 50% of households never choose consumption of less preferred foods, reduction of variety of foods or reduction of food quantity,

Table 1
Binary triplets characterizing the joint and marginal probabilities of choice of coping strategies (%).

Choice (j)	Combination of strategies (j)	Definition	Joint probability	Marginal		
				Less preferred food (LPF)	Reduce variety food (RVF)	Reduce size of food (RSF)
1	$(I_{LPF}=0, I_{RVF}=0, I_{RSF}=0)$	None	62.59	–	–	–
2	$(I_{LPF}=1, I_{RVF}=0, I_{RSF}=0)$	LPF only	5.67	5.67	–	–
3	$(I_{LPF}=0, I_{RVF}=1, I_{RSF}=0)$	RVF only	1.93	–	1.93	–
4	$(I_{LPF}=0, I_{RVF}=0, I_{RSF}=1)$	RSF only	3.22	–	–	3.22
5	$(I_{LPF}=1, I_{RVF}=1, I_{RSF}=0)$	LPF & RVF	6.25	6.25	6.25	–
6	$(I_{LPF}=1, I_{RVF}=0, I_{RSF}=1)$	LPF & RSF	2.53	2.53	–	2.53
7	$(I_{LPF}=0, I_{RVF}=1, I_{RSF}=1)$	RVF & RSF	3.03	–	3.03	3.03
8	$(I_{LPF}=1, I_{RVF}=1, I_{RSF}=1)$	LPF & RVF & RSF	14.77	14.77	14.77	14.77
Total			100.00	29.22	25.99	23.55

Note: A '1′ indicates that the coping strategy is adopted, while a '0′ indicates that the strategy is not adopted.

Table 2
The interdependence of the different coping strategies.

	Coping strategies		
	LPF	RVF	RSF
$P(C_k=1)$	29.22	25.99	23.55
$P(C_k=1\|C_{RSF}=1)$	73.45	75.60	–
$P(C_k=1\|Y_{RVF}=1)$	80.89	–	68.51
$P(C_k=1\|Y_{LPF}=1)$	–	71.93	59.19
$P(C_k=1\|Y_{RVF}=1\ \&\ Y_{RSF}=1)$	82.95	–	–
$P(C_k=1\|Y_{LPF}=1\ \&\ Y_{RSF}=1)$	–	85.38	–
$P(C_k=1\|Y_{LPF}=1\ \&\ Y_{RF}=1)$	–	–	70.26

Y_k is a binary variable representing the participation status with respect to coping mechanism k (k = LPF, RVF and RSF); *** indicates statistically significance difference at the 1% level. The comparison is between unconditional probability and conditional probability in each coping mechanism.

Table 3
Transition matrix on choice of coping strategies.

Year			Choice coping strategies (%ge)			
2012	2014	2016	All	Less preferred food	Limit the variety of foods	Limit the size of foods
Yes	Yes	Yes	9.7	5.0	3.7	3.3
		No	7.3	5.5	5.0	4.7
	No	Yes	9.6	7.4	6.6	5.5
		No	13.0	13.9	14.7	14.8
No	Yes	Yes	6.5	4.5	4.1	3.0
		No	11.6	10.5	9.9	10.7
	No	Yes	11.7	13.0	10.9	9.0
		No	30.6	40.1	45.1	49.0

respectively. However, about 3 – 5% of households are always choosing these strategies as coping options.

2.2.2. Nutrition variables: Calories, protein and iron

We measure household nutrition using food consumption data from the survey, from which we derive food security and dietary quality. Based on the various food items consumed by all household members over a period of seven days, we calculated calorie and micronutrient consumption per adult equivalent using food composition tables for Ethiopia (see Teklewold et al., 2019). The average per capita calorie consumption is about 2111 kcal (Table 4). Households who use one or more of the identified coping strategies had lower average per capita calorie consumption than households who don't use the strategies. In Ethiopia, the national average per adult equivalent calorie consumption is about 1950 kcal. This is lower than the average daily per capita calorie requirement needed to maintain the health of the population, 2100 kcal. The average protein and iron consumption per day per person is about 55 and 17 g.

2.2.3. Explanatory variables

Table 5 presents important information on indicators of demographic and socioeconomic characteristics that are hypothesized to affect household food and nutrition security. The use of weather data as exogenous sources of shocks in various empirical models to estimate the ex-post impact of weather are now becoming common among economists (Hill & Porter, 2017). In this study, we quantify the consumption adjustment effect of observed weather shocks by controlling the temperature, intensity and variability of rainfall variables. We derived long-term mean rainfall and temperature and coefficient of variation of rainfall variables and included these in the regression model to control for covariate risk factors. The satellite-based monthly climate data (1986–2016) with high resolution (0.5 X 0.5 degrees) grid were accessed from the Climate Research Unit (CRU) of the University of East Anglia (Harris & Jones, 2017). The survey recorded geo-referenced household level latitude and longitude coordinates using Global Positioning System (GPS) devices, which allow for the linking of household-level data to these historical climate variables. The survey timing is of great importance to this study as it covers a period which included drought years. Because of the predominance of rain-fed agriculture, the rainfall fluctuations during this time were captured as important agricultural shocks.

We also followed Quisumbing (2003) to construct a subjective shocks index capturing the most common shocks affecting the household, such as an increase in food prices, household member death, drought, illness, flooding, livestock death, output price declines, and input price increases. Households' responses to the presence of each of these shocks (either yes or no) were coded as unfavourable or favourable disturbance outcomes. By averaging over the number of shocks asked (eight questions), we created an index that provides a value close to one for the highest level of shocks.

We include land and livestock ownership (in Tropical Livestock Units, TLU) as a measure of household wealth and to control a household's response to risk exposure (Carter & Lybbert, 2012). Both are indicators of the household's dependence on agriculture and rainfall, as well as income diversification. Comparison of land and livestock ownership variables indicates that those who are not involved in the different coping strategies possess statistically higher land and livestock sizes compared with those households who use coping strategies. Both livestock and land are unequally distributed, reflecting unequal capacity to smooth consumption (Christiaensen & Subbarao, 2005). A common indicator to proxy income diversification is the income derived from off-farm employment and remittance incomes. We thus include two dummy variables, whether the household receives a remittance and whether the household participates in non-farm work, as an indicator of additional income influencing consumption. Although there are many reasons that households diversify their sources of income, many rural households do so to smooth their income, especially when they are unable to smooth their consumption by other means (Barrett et al., 2001). Thus, we

Table 4
Household dietary intake with coping strategies.

	Coping strategies			Participating in:		
	All sample	Non-participant	Participant	Less preferred food	Limit the variety of foods	Limit the size of foods
Calorie intake per adult equivalent, Kcal per day	2111.13 (864.69)	2320.81 (682.96)	1760.26 (1010.87)	1752.61 (1004.37)	1779.79 (1016.32)	1750.54 (1017.84).
Protein intake per adult equivalent, gm per day	55.80 (66.37)	61.78 (81.04)	45.80 (25.07)	45.51 (24.98)	46.04 (24.95)	45.16 (25.11)
Iron intake per adult equivalent, mg per day	17.34 (29.01)	22.05 (33.90)	9.47 (15.06)	9.51 (15.12)	9.90 (15.68)	9.89 (16.05)

*Numbers in parentheses are standard deviations.

Table 5
Description and summary statistics of the variables used in the empirical estimation.

Variable	Description	All		Coping strategies participation				Participating in:					
				Non-participant		Participant		Less preferred food		Limit variety of foods		Limit size of foods	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Male	1 = if male headed household	0.76	–	0.77	–	0.73	–	0.73	–	0.73	–	0.73	–
Age	Age of the household head, years	46.25	15.42	45.81	15.34	46.99	15.53	46.87	15.60	46.91	15.54	47.11	15.60
HHedu	1 = if household head is literate	0.32	–	0.33	–	0.31	–	0.30	–	0.32	–	0.31	–
HHsize	Number of household member	5.09	2.36	5.10	2.36	5.07	2.36	5.06	2.37	5.09	2.36	5.06	2.38
Marital	1 = if household head is married	0.76	–	0.77	–	0.74	–	0.74	–	0.74	–	0.73	–
Tlu	Tropical livestock unit	3.26	3.87	3.41	3.85	3.02	3.89	3.04	3.94	3.05	3.99	2.95	3.99
Farmsize	Farm size, ha	0.98	1.32	1.07	1.34	0.84	1.26	0.83	1.26	0.84	1.29	0.80	1.26
Credit	1 = if borrowed money	0.25	–	0.25	–	0.27	–	0.26	–	0.26	–	0.25	–
Nonfarm	1 = if participated in non-farm activities	0.07	–	0.08	–	0.06	–	0.06	–	0.06	–	0.06	–
Remitance	1 = if household received remittances	0.40	–	0.40	–	0.40	–	0.40	–	0.39	–	0.36	–
Expenditure	Annual non-food expenditure, Birr	171.66	628.66	173.41	590.22	168.74	688.29	170.28	767.68	179.05	809.86	174.14	842.00
PSNP	1 = if participated in safety net	0.24	–	0.23	–	0.26	–	0.25	–	0.26	–	0.27	–
Distroad	Distance to main road, km	9.34	5.61	9.48	5.58	9.10	5.66	8.98	5.65	9.00	5.66	9.13	5.72
Distmkt	Distance to main market, km	36.21	13.10	35.75	13.48	36.99	12.40	36.92	12.39	37.38	12.14	37.49	12.24
Shock	Shock index (1 = Worst)	0.09	0.11	0.07	0.10	0.12	0.12	0.12	0.12	0.13	0.13	0.12	0.12
RF	Mean annual rainfall, mm	1041.91	315.17	1024.93	323.35	1070.33	298.87	1077.0.29	295.69	1074.14	303.80	1082.22	294.29
CVRF	Coefficient of variation of rainfall	0.97	0.05	0.97	0.05	0.96	0.06	0.96	0.06	0.96	0.06	0.96	0.06
Temp	Mean daily temperature, 0C	19.84	2.68	19.84	2.64	19.83	2.73	19.86	2.77	19.90	2.84	19.86	2.72
Tigray	1 = if Tigray region	0.10	–	0.12	–	0.08	–	0.08	–	0.09	–	0.07	–
Afar	1 = if Afar region	0.03	–	0.03	–	0.03	–	0.03	–	0.03	–	0.03	–
Amhara	1 = if Amhara region	0.21	–	0.23	–	0.17	–	0.17	–	0.14	–	0.15	–
Oromia	1 = if Oromia region	0.19	–	0.19	–	0.20	–	0.20	–	0.22	–	0.22	–
Somalie	1 = if Somalia region	0.06	–	0.06	–	0.06	–	0.06	–	0.07	–	0.06	–
Bgumuz	1 = if Bensangul-Gumuz region	0.03	–	0.03	–	0.03	–	0.03	–	0.04	–	0.04	–
SNNP	1 = if SNNP region	0.26	–	0.22	–	0.33	–	0.34	–	0.34	–	0.34	–
Gambelia	1 = if Gambela region	0.03	–	0.03	–	0.03	–	0.03	–	0.03	–	0.04	–
Harari	1 = if Harari region	0.04	–	0.04	–	0.03	–	0.02	–	0.02	–	0.02	–

explore how the households' non-farm participation and incidence of remittance have an effect on choice of coping strategies and dietary intake.

Households' access to roads and markets and their demographic characteristics are considered as proxies for their consumption smoothing capacity. Access to such infrastructure is measured by the average distance to reach the nearest road and input and output market; greater distances can negatively influence participation in alternative income-generating opportunities by increasing travel time and transport costs. In both groups of households (those that do and don't use coping strategies), about a quarter of the households are headed by a woman and one-third of the households are literate. Educated individuals are expected to be less vulnerable because they can adapt more easily to changing situations (Christiaensen & Subbarao, 2005).

We also control for the possible role of social safety net programs by including a dummy variable taking the value of one if the farmer participates in productive safety net programs (PSNP). In the developing world, where production risks are high due to a number of factors (e.g., unreliable rainfall, incidence of pests and diseases), farmers are less likely to adopt technologies and increase production in the absence of farm insurance to smooth consumption during crop failure. Social safety nets are needed to address risks, poverty and vulnerability, and can help farm households' smooth consumption and maintain productive capacity by reducing the need to liquidate assets (Barrett, 2005; Sabates-Wheeler & Devereux, 2010).

2.3. Analytical framework

2.3.1. The model

In the presence of agricultural income shocks, it is assumed that households consider a number of possible ex-post consumption adjustment coping strategies (such as relying on less preferred foods, reducing variety of foods and reducing quantity of foods), and choose a single or combination of coping actions that maximize the expected benefit conditional on the decision to undertake a coping strategy. Because these strategies are correlated, the choice decision is fundamentally multivariate, and univariate modeling would exclude useful economic information that is found in interdependent decisions (Kassie et al., 2015; Teklewold et al., 2019).

We model a two-stage estimation procedure (Bourguignon et al., 2007), using endogenous switching regression with a multivariate probit model (MVP) to estimate the choice of coping actions and their impact on a household's nutrition outcome. The multivariate empirical approach not only jointly models the effect of the different explanatory variables on each of the strategies but also identifies the association between the same unobserved characteristics and the choice of the different strategies. This implies that the approach is more efficient than the univariate methods of analyzing choice of strategies independently.

Given the non-random choice of coping strategies among households, those who adopt coping strategies are likely to diverge from those who do not adopt the strategies in the distribution of their observed and unobserved characteristics (such as motivation and ability). Thus, selective participation through individual household choice means that non-participants and participants are not directly comparable. Unless a proper method is used, comparison of outcomes between participants and non-participants using standard econometric approaches (e.g., ordinary least-squares) would yield selection bias on both observables and unobservables. This is because the determinants of participation in coping strategies can also be expected to impact the outcome variables even in the absence of the coping strategies. Thus, the endogenous switching regression with panel data can help tackle the selection bias in the impact estimates and build a statistical comparison group of farmers comparable to coping strategies users.

The MVP model with the Mundlak (1978) approach is first estimated to find estimates of the time-variant individual heterogeneity (Inverse Mills Ratios) [3]causing selection bias. The nutrition outcome equations are then estimated by fixed effects including Inverse Mills Ratios estimates from the first stage as additional explanatory variables. The Mundlak approach allows for including the means of the time-varying explanatory variables, as a proxy for removing the time-invariant individual effects, and Inverse Mills Ratios take care of time-varying heterogeneity[4].

Let the i^{th} household ($i = 1, \ldots, N$) be exhibiting a choice among the different ex-post coping actions. Let U_k characterize the benefit of adopting the k^{th} coping strategies, where k indicates the choice of consumption adjustment options such as relying on less preferred food (LPF), reducing variety of foods (RVF) and reducing size of food portions (RSF); and let U_j denote the benefits to the household from any coping strategies other than the k^{th} strategies. The household chooses to use the k^{th} actions if the benefit, U_k, is higher than the benefit that could be found from all other remaining coping actions, U_j; such that $U_k > max(U_j)$ where k = LPF, RVF, RSF and k ≠ j. The utility that the farmer derives from the choice of the k^{th} coping action is a latent variable determined by observed socioeconomic and climate variables and expressed as follows:

$$U^{*}_{itk} = X'_{it}\beta_k + \alpha + \varepsilon_{itk} \qquad (k = LPF, RVF, RSF) \tag{1}$$

where X'_{it} is a matrix of household features and climate variables, β_k are parameters to be estimated, α is unobserved time-constant heterogeneity and ε_{itk} is the error term.

The unobserved latent variable in Eq. (1) converts into the observed binary outcome equation for each choice as follows:

$$\mathrm{I_{itk}} = \begin{cases} 1 \text{ if } \mathrm{U^{*}_{itk}} > 0 \\ 0 \text{ otherwise} \end{cases} \qquad (\mathrm{k} = \mathrm{LPF}, RVF, RSF) \tag{2}$$

The system of equations from (2) is estimated using the multivariate probit model. The error terms jointly follow a multivariate normal distribution with zero conditional mean and variance normalized to unity (for identification of the parameters) where $(u_{LPF}, u_{RVF}, u_{RSF}) \sim MVN(0, \Omega)$ and the symmetric covariance matrix Ω is given by:

$$\Omega = \begin{bmatrix} 1 & \rho_{LPF,RVF} & \rho_{LPF,RSF} \\ \rho_{RVF,LPF} & 1 & \rho_{RVF,RSF} \\ \rho_{RSF,LPF} & \rho_{RSF,RVF} & 1 \end{bmatrix} \tag{3}$$

where ρ (rho) denote the pairwise correlation coefficient of the error terms to any two coping strategy equations to be estimated in the model. The non-zero off-diagonal elements in the variance–covariance matrix show the correlation of error terms between the different equations. This notion entails that Eq. (2) is an MVP model that explains the decisions to adopt coping strategies jointly.

The decision to use one or more of the three coping strategies results in eight alternative groups of choices (as shown in Table 1). For each alternative combination of coping strategies, the relationship between the dietary outcome variables and a set of control variables is estimated by a fixed effect model as:

[3] The Inverse Mill's Ratio (λ_{itj}) is defined as the ratio between the standard normal probability distribution function and the standard normal cumulative distribution function. It is the selection term that captures all potential effects of the difference in unobserved variables.

[4] The time varying variables are age of the head, household size, livestock size, shock index and weather variables.

$$Y_{itj} = \delta Z_{itj} + \theta_j + u_{itj} \quad \text{if} \quad I_{it} = j \quad \text{for} \quad j = 1, \ldots, 8 \tag{4}$$

where $Y_{itj}^{'}s$ are vectors of outcome variables (defined as per adult equivalent consumption of calories, protein and iron) of the i^{th} farm household for coping strategies category j at time t; the error term $(u_{itj}^{'}s)$ is distributed with $E(u_{itj}|X, Z) = 0$ and $\text{var}(u_{itj}|X, Z) = \sigma_j^2.Y_{itj}$ is observed if and only if coping strategy j is used; Z is a vector of covariates influencing nutrition outcomes, and θ is unobserved time-invariant household heterogeneity.

We obtain the Inverse Mills Ratio (λ) variables from Eq. (2) and include them in Eq. (4) to capture individual heterogeneity underlying selection bias[5]. From Eq. (4) this is given as:

$$Y_{itj} = \delta Z_{itj} + \sigma_j \widehat{\lambda}_{itj} + \theta_j + u_{itj} \quad \text{if} \quad I_{it} = j \quad \text{for} \quad j = 1, \ldots, J \tag{5}$$

where σ_j is the parameter of coefficients for $\widehat{\lambda}_{itj}$ showing the covariance between $\varepsilon^{'}s$ and $u^{'}s$.

A two stage estimation procedure have been commented for being sensitive to misspecification. The lack of identification is often a problem when variables expected to correlate with the choice decisions (X) are the same as those influencing the subsequent outcome equations (Z). Thus, to enable identification, we established a selection instruments, such as distance to main road and distance to main market, hypothesized to directly affect the choice decisions but not the nutrition outcome variables. We test the assumption that these instrument variables affect the choice of coping strategies but do not influence the nutrition outcome. The results confirm that the instruments are successful at enabling identification.

2.3.2. Impact estimation

We estimate the average difference in nutritional outcomes among users of the different coping strategies and non-users, using the above Eq. (5). The actually observed average nutritional outcome for users of coping strategies (that is, for j = 2, … , 8) and for non-users of coping strategies (for j = 1) is given as:

$$E(Y_{ij}|I_i = j) = \delta_j Z_{ij} + \sigma_j \lambda_{ij} \tag{6}$$

On the other hand, to examine the role of coping actions in household nutrition for the different coping strategies, we estimate the counterfactual average nutritional outcome for users had they decided not to use coping strategies (using Eq. (6)):

$$E(Y_{i1}|I_i = j) = \delta_1 Z_{ij} + \sigma_1 \lambda_{ij} \text{for j} = 2, \ldots, 8 \tag{7}$$

The average difference in nutritional outcomes between participants and their matches provides the unbiased estimates of the average treatment effect on the treated (ATT), where "treatment" means participation in one or more coping strategies. This estimand is based on the average difference in nutrition outcome if everyone who adopted a combination of coping strategies had instead not adopted coping strategies. This is given by the difference between Eqs. (6) and (7) for j = 2, … , 8:

$$ATT = (Y_{ij}|I_i = j) - E(Y_{i1}|I_i = j) = Z_{ij}(\delta_j - \delta_1) + \lambda_{ij}(\sigma_j - \sigma_1) \tag{8}$$

3. Empirical results and discussions

3.1. The choice of coping strategies

The estimation results from the MVP model are shown in Table 6. The MVP model is estimated using the maximum likelihood method, taking household level observations as a unit of analysis. The Wald test of the hypothesis that the regression coefficients in all the three equations are jointly equal to zero is rejected – showing the estimated empirical model behaves well with the data. The MVP model estimates contrast substantially across the three equations ($\chi^2(117) = 2804$, p = 0.000), signifying the heterogeneity in adoption of coping strategies and consequently supports separate analysis for each strategy instead of aggregating them into one coping strategy variable. The coefficients of the mean of the time-varying covariates are jointly statistically different from zero in all the regression equations. This confirms the presence of correlation between unobserved household fixed effects and observed covariates, thus supporting the use of MVP with Mundlak's approach.

All covariance matrix element estimates (rho) are statistically significant, [$\chi 2(3) = 7106$, p = 0.000)], showing the rejection of the null hypothesis of independence of the decisions to adopt the different ex-post consumption adjustment coping strategies. Consistent with the results on conditional and unconditional adoption probabilities reported in Table 3, the estimated correlation coefficients have positive signs in all three pair cases. This reveals that coping decisions are made interdependently, where the probability of adopting a given strategy is conditioned on whether or not a strategy in the subset has been adopted. The correlations between consumption of low diversified food with consumption of less preferred food (86%) and reducing the size of food portions (82%) are the highest. The result corroborates with Gao and Mills (2018), who reflect that households may consider various strategies given the fact that a single strategy cannot be enough to respond to the adverse effects of shocks. The cross-correlations among coping strategies may have an important policy implication in that a shock or other factor that affects the choice of a given strategy can have spillover effects on the other strategies as well.

The MVP model result reveals that the choice of the different consumption adjustment coping strategies is significantly affected by the wealth status of the household as well as by both idiosyncratic and covariate shocks. This supports the arguments that households do not randomly select coping activities but follow a structured process that takes into account types and extents of shocks as well as household characteristics, assets, and the diversity of household income sources (Yilma et al., 2014; Hill & Porter, 2017).

We found asymmetric effects of non-farm work participation on the choice of the different consumption adjustment coping strategies. While participation in non-farm work decreases the probability of consuming less preferred foods and reducing portion size of meals, we don't find a statistically significant relationship between participation in non-farm work and consumption of diversified food. The result confirms the important role of alternative income generating activities in increasing household income and responding to income shocks (Kijima et al., 2006; Ito & Kurosaki, 2009). From the long-term perspective, the importance of non-farm jobs in poverty reduction has been documented in the literature as a major option to increase household income and consumption (Cherdchuchai & Otsuka, 2006).

As expected, the estimated coefficients on self-reported shocks are positive and statistically significant for all coping actions. The result implies that the different type of shocks reported by the household increased the probability that the household will adjust consumption into less preferred foods, less diversified foods and reduced portion sizes. However, the coefficients of the interaction terms of the shock index with non-farm participation are negative and significant for the choice of all coping strategies. This suggests that households' responses to different type of shocks for consumption adjustment differ between participants and non-participants in non-farm work. That is, with shocks, those households who work non-farm are less likely to choose consumption adjustment coping strategies, compared with those households who do not participate in non-farm work. This may imply that off-farm work provides access to means of mitigating shocks and hence protects households' consumption shortfall.

Similarly, we also found a significant role of weather shocks in determining farmers' choice of consumption adjustment coping actions.

[5] See Bourguignon et al. (2007) for the derivation of selection bias correction terms from the choice model.

Table 6
Parameter estimates of the Multivariate probit model with Mundlak approach – choice of consumption adjustment coping strategies.

Variables	Less preferred food		Limit variety of foods		Limit the size of foods	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Male	−0.05	0.051	−0.046	0.046	−0.019	0.051
Age	0.001	0.001	0.002	0.001	0.003**	0.001
HHedu	−0.064*	0.033	−0.012	0.032	−0.024	0.038
HHsize	0.007	0.008	0.006	0.007	0.014*	0.008
Marital	0.000	0.049	0.014	0.045	−0.006	0.052
Tlu	−0.032***	0.010	−0.032***	0.010	−0.051***	0.010
Tlu_Squared	0.002***	0.001	0.002***	0.001	0.002***	0.000
Farmsize	−0.292***	0.039	−0.280***	0.037	−0.280***	0.041
Farmsize-Squared	0.049***	0.007	0.050***	0.007	0.050***	0.008
Credit	0.071**	0.034	0.047	0.031	0.019	0.035
Nonfarm	−0.192***	0.060	−0.095	0.058	−0.164**	0.065
Remitance	−0.054	0.050	−0.063	0.058	−0.065	0.056
Expenditure	0.000	0.000	0.000*	0.000	0.000	0.000
PSNP	0.046	0.042	0.099**	0.039	0.186***	0.040
Distroad	−0.009***	0.003	−0.011***	0.003	−0.005	0.003
Distmkt	−0.003**	0.001	0.000	0.001	0.001	0.002
Shock	1.767***	0.130	2.122***	0.142	1.914***	0.140
Shock X Offarm	−1.495***	0.462	−0.786**	0.384	−0.923***	0.394
RF	0.002***	0.000	0.002***	0.000	0.002***	0.000
RF-Squared	−0.000***	0.000	−0.000***	0.000	−0.000***	0.000
CVRF	−0.439	0.577	−2.366***	0.491	−0.986*	0.530
Temp	−0.223***	0.060	−0.250***	0.059	−0.041	0.076
Temp-Squared	0.005***	0.001	0.006***	0.001	0.001	0.002
Year_2014	−0.036	0.033	−0.064*	0.035	−0.037	0.031
Year_2016	0.052	0.061	−0.043	0.066	−0.147**	0.061
Tigray	0.392***	0.092	0.375***	0.095	0.201*	0.108
Afar	0.282**	0.117	0.107	0.112	0.218*	0.117
Amhara	−0.006	0.091	−0.076	0.091	−0.021	0.106
Oromia	0.178*	0.097	0.186**	0.090	0.303***	0.103
Somalie	0.320***	0.096	0.264***	0.096	0.147	0.102
Bgumuz	0.061	0.119	0.274**	0.122	0.404***	0.131
SNNP	0.316***	0.101	0.074	0.096	0.242**	0.115
Gambelia	0.059	0.118	0.084	0.118	0.253*	0.134
Harari	−0.240**	0.112	−0.283***	0.096	−0.105	0.118
Constant	−2.954*	1.713	−0.976	1.769	−2.711	1.804
RHO:						
LPF			0.855***	0.007	0.740***	0.011
RVF					0.816***	0.008
Joint significance of location variables, $\chi^2(8)$	75.87***				65.50***	
			84.41***			
Joint significance of time varying variables, $\chi^2(8)$	36.92***				22.95***	
			25.80***			
Joint significance of instruments:						
First stage (Choice of coping strategies):	χ^2 (6) = 28.66***					
Second stage (Nutrition outcome):						
Calorie:	F(2, 9596) = 1.59					
Protein:	F(2, 9591) = 0.97					
Iron:	F(2, 9591) = 0.37					
Observations	9886					
Model chi-square	Wald $\chi^2(1\,1\,7) = 2972$; Prob > $\chi^2 = 0.000$					
Likelihood ratio test $RHO_{LPF,RVF} = RHO_{LPF,RSF} = RHO_{RVF,RSF}$: $\chi^2(3) = 7106$; Prob > $\chi^2 = 0.000$						

Note: ***, ** and * denote significance at 1%, 5% and 10%. All regressions include household time average variables. Robust clustered standard errors at the household level.

This is expected because weather shocks such as extreme weather conditions affecting agricultural production are a major negative influence on a household's welfare, causing the affected households to shift their consumption patterns (Dercon, 2004; Yilma et al., 2014; Hill & Porter, 2017). The results also indicate that the precipitation and temperature variables exhibit non-linear effects, showing that the choice of ex-post coping strategies is responsive to climate extremes, and that different households may respond to these shocks differently.

The hypothesis that asset ownership correlates with the choice of consumption adjustment coping strategies is confirmed. The relationships of assets to coping actions are non-linear, with U-shaped relationships. The result reveals the distinctive outcome of asset ownership and co-existence of consumption smoothing and consumption adjustment coping strategies. This is somewhat consistent with Carter and Lybbert (2012), who found two different smoothing regimes in their threshold estimation approach for Burkina Faso. Our results reveal that the effect of shocks is more severe for the poor, who are less insured against shocks ex-ante and are therefore more likely to engage in consumption adjustment coping actions (Isaac et al., 2021). Our result showing greater use of consumption adjustment coping actions with lower levels of asset ownership agrees with Isaac et al. (2021), in which households cope with threats to their livelihood by reducing food consumption. At that stage where households are destitute or virtually asset poor, a household's ability to generate either current or future income is severely diminished and hence it is faced with the options for choosing consumption adjustment coping strategies. As in Barrett (2005) and Carter and Barrett (2006), the poorest households with lack of land and livestock resources may resort to coping strategies, listing them toward chronic poverty, sometimes conceptualized as a poverty trap.

Further, the results show the role of assets in consumption

smoothing. Households with higher levels of asset ownership can manage to smooth consumption by disposing of their assets and hence are less likely to engage in the three ex-post coping actions discussed in this paper (Zimmerman & Carter, 2003, Hoddinott, 2006). In these cases, households may smooth consumption by giving up some assets that are held primarily as adaptive strategies or forms of self-insurance: for example, selling livestock (such as goats) or renting out or borrowing against land. Selling livestock is an important coping strategy for rural households because such assets are held as a form of liquid savings for, among other things, coping with natural disasters (Dercon, 2002; Quandt, 2021). Liquidating livestock may make more sense when there is a covariate environmental shock such as drought or flood because these shocks reduce available grazing land and some or all of the livestock could be lost anyway (Dercon, 2002).

We expected that households would manage consumption smoothing partly through public actions such as the productive safety net program (PSNP) that mitigate the impact of repeated droughts and reduce household's vulnerability to food insecurity. However, our results indicate a positive correlation between participation in PSNP and consumption adjustment coping strategies. This implies that the moderating effect of social protection programs on consumption smoothing security is inadequate. As a short-term effect, the result corroborates evidence that when food or cash has been distributed to households as part of safety net programs, this has not immediately resulted in an increase of household food consumption as expected (Corbett, 1988). This could be because household strategies with social protection program at times of crisis may be focusing on assets protection to safeguard the household's future survival and reduce vulnerability to similar shocks in the future, rather than on increasing their current food consumption levels. To build the adaptive capacity of the household, the income transfer function or insurance mechanisms of the safety net programs can also help investment in agriculture and resilience building (Devereux & Sabates-Wheeler, 2004; Abdulai et al., 2005).

3.2. Nutrition effects of coping actions

The expected amount of consumption under actual and counterfactual conditions and the average effects of using ex-post coping actions on households' nutrition outcome are shown in Table 7. Columns A, D and G respectively present the actual calorie, protein and iron consumption outcome, while columns B, E and H present the respective counterfactual outcomes. Columns C, F and I present the average nutritional effects (ATT), computed as the difference between the above respective columns. The results of the decomposition analysis in general reveal the overall difference of using coping strategies.

Results show that the adoption of any of the coping strategies, whether individually or jointly, provides lower nutrition outcomes compared with non-adoption. In all counterfactual cases, farm households who actually implemented the different coping actions would obtain higher per capita nutrition consumption outcomes if they did not implement the coping strategies. However, the per capita calorie consumption loss from consuming less preferred foods and reduced portion size of meals (that is 686 and 679 Kcal per day, respectively) is higher than the calorie consumption loss from consuming less diversified foods (that is 491 Kcal per day). We found a calorie consumption loss of greater than 10% from choosing less preferred foods and reduction of meal portion sizes jointly (LPF & RSF) than using each of these coping actions individually. But when the household choose less diversified food jointly with less preferred foods (RVF & LPF), the per capita calorie consumption loss is reduced by 1% than choosing less preferred food only. Similarly, compared with the choice of reduced portion size of meals, we observed a 3% reduction of per capita calorie consumption loss when the household choose to reduce portion size of meals jointly consuming less diversified food (RVF & RSF). The higher calorie consumption loss from choosing LPF and RSF jointly (that is 771 Kcal per day) is reduced by about 10%, when choosing the three strategies jointly. We also determine the effects of different coping actions on per adult equivalent consumption of protein and iron nutrients. These results are presented in Table 7 as well. Similar to the above results, the consumption of protein and iron are lower when these coping actions are applied.

This empirical observation that households compromise their dietary intake levels with the use of the different consumption adjustment coping strategies suggests that the strategies adopted for coping may be resilience erosive and therefore the consequences of these actions could potentially exacerbate households' vulnerability to shocks (Isaac et al., 2021). Thus, the rising levels of undernourishment with such coping actions should be interpreted as signaling one of their costs (Corbett, 1988).

Figs. 2 and 3 present the correlations between weather shock and per capita calorie and protein consumption, respectively, when conditioned

Table 7
Average expected nutritional outcome with participation on different coping strategies.

Strategies	Calorie consumption (Kcal./Percapita/day)			Protein consumption (mg/ Percapita/day)			Iron consumption (mg/ Percapita/day)		
	Actual calorie consumption if household did participate (A)	Counter factual calorie consumption if household didn't participate (B)	Participation Effects (C)	Actual protein consumption if household did participate (D)	Counter-factual protein consumption if household didn't participate (E)	Participation Effects (F)	Actual iron consumption if household did participate (G)	Counterfactual iron consumption if household didn't participate (H)	Participation Effects (I)
LPF only	1547.37 (470.10)	2233.23 (183.71)	−685.86 (21.31)***	41.95 (12.94)	69.87 (10.22)	−27.92 (0.69)***	12.80 (4.47)	28.76 (3.75)	−15.95 (0.25)***
RVF only	1727.24 (697.43)	2218.45 (183.38)	−491.22 (52.18)***	47.32 (17.41)	69.39 (10.18)	–22.07 (1.45)***	15.45 (7.56)	28.78 (4.29)	−13.33 (0.63)***
RSF only	1545.92 (495.35)	2225.09 (190.50)	−679.16 (29.76)***	41.68 (14.63)	70.13 (10.39)	−28.45 (1.01)***	13.73 (6.41)	28.83 (4.14)	−15.10 (0.43)***
LPF & RVF	1540.47 (399.81)	2217.49 (197.87)	−677.03 (17.94)***	40.87 (13.25)	69.15 (10.80)	−28.28 (0.69)***	13.10 (4.07)	29.16 (4.41)	−16.06 (0.24)***
LPF & RSF	1437.24 (711.04)	2208.09 (187.51)	−770.85 (46.51)***	37.51 (19.25)	69.16 (10.32)	−31.66 (1.38)***	13.02 (7.13)	29.26 (4.39)	−16.23 (0.53)***
RVF & RSF	1562.53 (658.08)	2224.72 (189.47)	−662.19 (39.54)***	41.31 (18.19)	69.69 (10.31)	−28.39 (1.21)***	13.57 (6.76)	29.56 (4.64)	−15.99 (0.47)***
LPF & RVF & RSF	1530.43 (355.05)	2224.93 (206.13)	−694.51 (10.74)***	39.74 (10.92)	70.00 (11.97)	−30.26 (0.42)***	15.12 (7.11)	29.87 (4.71)	−14.74 (0.22)***

Note: LPF is Less Preferred Foods; RVF is Reduce Variety of Foods; RSF is Reduce Size of Foods; Numbers in parentheses are standard errors; *. ** and *** indicate statistical significance at 10%. 5% and 1% level, respectively.

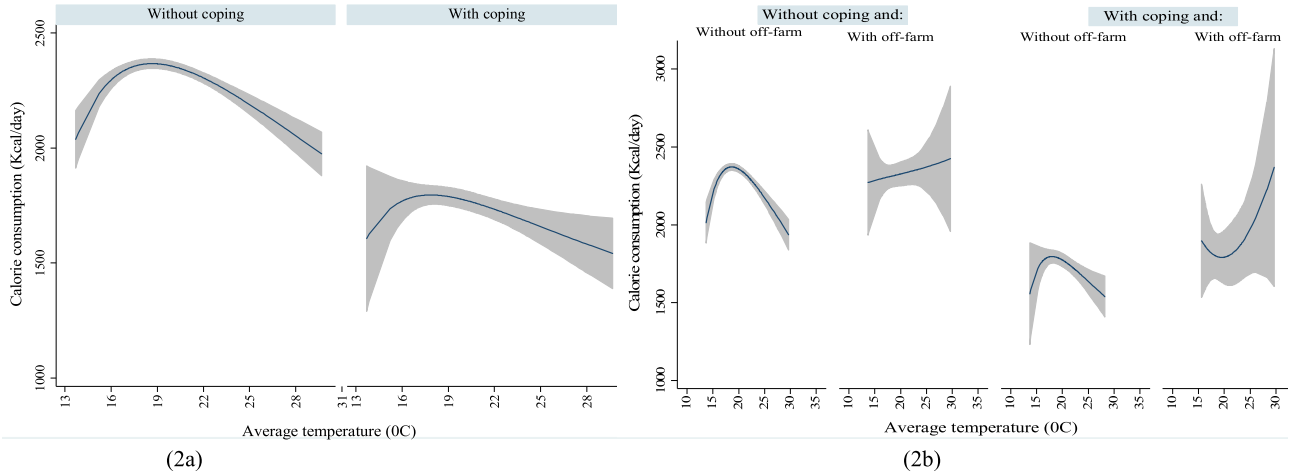

Fig. 2. The correlation between household calorie intake and shock with and without coping actions, and off-farm participation.

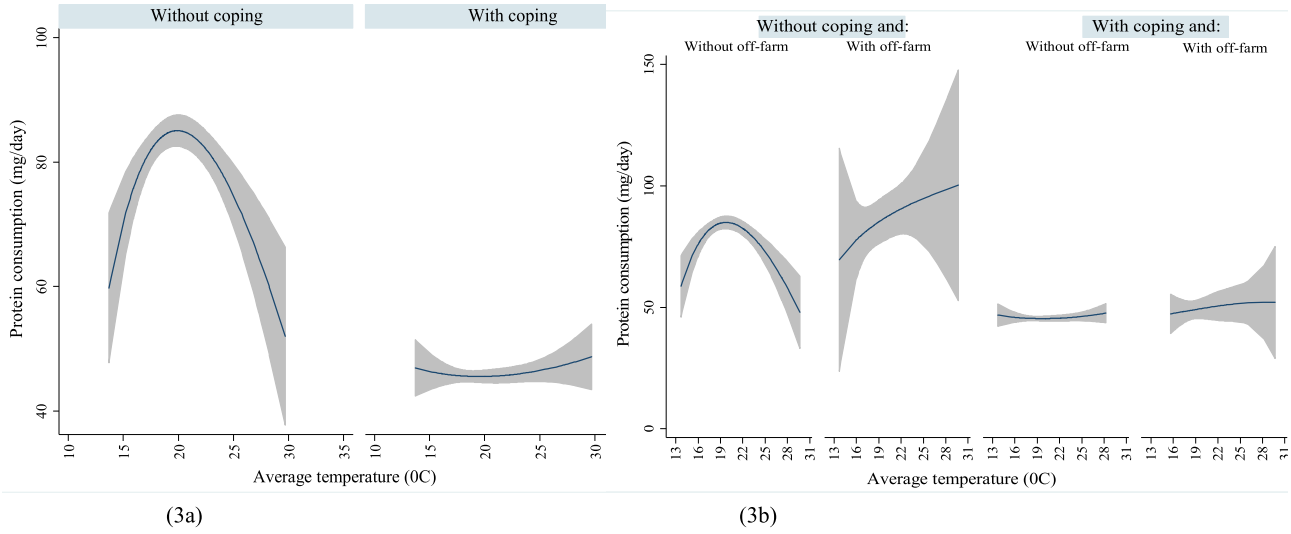

Fig. 3. The correlation between household protein intake and shock with and without coping actions, and off-farm participation.

with coping actions and non-farm work. This can help us understand the degree of households' resilience – defined as a household's ability to maintain its nutrition security – and whether resilience-enhancing economic factors such as alternative income generating actions allow households to absorb the impacts of weather shocks on well-being outcomes such as nutrition security. The results indicate that regardless of the use of consumption adjustment coping actions, households' calorie and protein consumptions are lower with extreme temperature (Figs. 2a and 3a). However, the observed degree of shock-induced dietary intake reductions is higher for households undertaking coping actions. This implies that households that undertake coping actions have lower ability to absorb shocks and are less resilient (Carter & Lybbert, 2012).

We predict heterogeneous effects of weather shocks on household dietary intakes when the household is participating in income-augmenting actions. Figs. 2b and 3b depict the effect of non-farm work participation on increasing dietary intakes with increasing shocks. We observed that for both groups of households (those who use and don't use consumption adjustment coping actions), the per capita nutrient consumption is higher for non-farm work participants than for non-participants. The result is consistent with Babatunde and Qaim (2010), who found that non-farm income has a positive net effect on household calorie and micro-nutrient supply in Nigeria through contributing to overall household income and easing capital constraints to higher food production and farm income.

4. Conclusions

Climate change adaptation options are deemed to be important for building resilience and reducing vulnerability among rural households who are continually exposed to weather variability, crop diseases and pest attacks on agricultural production. With adaptation deficit, where it is difficult to undertake ex-ante adapting strategies or when these are insufficient, households are forced to attempt multiple ex-post coping strategies. While Adaptation deficits have greatly contributed to household's income fluctuations and consumption shortfalls, leading to food insecurity and nutritional deprivation, there has been limited understanding of households' decisions on the choices of a portfolio of ex-post consumption adjustment coping actions (such as consumption of less preferred foods, limiting food diversification and reducing the quantity of food) and how these coping mechanisms impact households' nutritional status. This study aims to fill the knowledge gaps on how household nutrition status is eroded by the portfolio of ex-post coping actions and broaden our understanding of the determinants of the choice of the different ex-post consumption adjustment coping strategies. Using a nationally representative panel data sets from rural households in Ethiopia, we employ endogenous switching regression in a

counterfactual framework to account for unobserved individual heterogeneity and selection bias causing endogeneity.

We find evidence that many households are unable to protect their consumption against exposure to economic and natural shocks. There is considerable heterogeneity on the choice of consumption adjustment strategies. The empirical results of the association between shocks and consumption is consistent with recent studies in Ethiopia (Yilma et al., 2014; Hill & Porter, 2017; Gao & Mills, 2018), but we further suggest the link between exposure to shocks and type of consumption adjustment coping actions. Non-farm work participation is found to moderate the effect of shocks on households' dietary consumption and reduce the likelihood that households engage in adverse consumption reducing coping actions. This evidence may suggest the need to activate alternative income-generating labor markets such as skills training and local investment opportunities to enhance the livelihood opportunities of the poor. However, the asymmetric effects of non-farm participation on the different consumption adjustment coping mechanisms; and the role of non-farm jobs in household nutrition security in the presence of shock require further empirical enquiry and will be an important avenue for future study.

We also find strong complementarity between the different consumption adjustment coping actions. The correlation among the coping strategies may suggest that households who were unable to smooth consumption ex-ante are more likely to engage in different ex-post consumption adjustment coping actions leading to a reduction in quality and quantity of dietary consumption. Moreover, the empirical results point that the choice of any of the coping strategies is associated with reduction of household's nutrition consumption. This implies consumption adjustment coping strategies individually or jointly are erosive of coping abilities, and the consequences of these actions could potentially exacerbate households' vulnerability to shocks. Hence, the results suggest that intervention is needed to strengthen the adoption of ex-ante strategies (such as agricultural water management, crop diversification, agro-forestry, soil conservation, etc) to reduce the adaptation deficit and avoid the cost of adopting ex-post consumption adjustment coping actions that erode households' resilience in terms of reduction of dietary intake.

CRediT authorship contribution statement

Tagel Gebrehiwot: Data curation, Supervision, Writing - review & editing. **Hailemariam Teklewold:** Conceptualization, Methodology, Writing - review & editing. **Mintewab Bezabih:** Writing - review & editing. **Robel Seifemichael:** Data curation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This article use data from the Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) of the World Bank. We are indebted to the editor and the anonymous reviewers for their incisive comments and suggestions that helped greatly improve the paper. The authors are grateful to the following sources of financial support: the Ministry of Foreign Affairs of Denmark (MFA) under the project "Building Resilience to Climate Change in Ethiopia: Exploring Options for Action (Project file no.: DFC File No. 18-07-KU)". The research results are independent, and the views and opinions expressed by project partners based on the research findings, do not necessarily reflect those of the MFA.

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